actually then occupied by the clear unossified cartilaginous basis of the bone, and not by marrow. The non-medullary character, therefore, assigned to fishes from the texture of their bones is strictly accurate. They may have cavities, but these are never occupied, as in higher classes, by marrow. The persistent cartilaginous basis of such partially ossified bones of fishes differs in chemical composition from the temporary cartilage of the bones of reptiles, birds and mammals, as Prof. Müller has shown *. It bears a closer resemblance to mucus: it requires a thousand times its weight of boiling water for its solution, and is neither precipitated by infusion of galls, nor yields any gelatine upon evaporation.

I have been induced to offer the foregoing comments on Mr. Tennant's Ichthyolite from having been asked more than once to explain the seeming contradiction given by such fossils to the law of the absence of medullary cavities in the bones of fishes, and from the circumstance of there being no precise explanation of the appearance, in reference to the cavities in the bones of higher Vertebrata, in the classical work of M. Agassiz on fossil fishes.

V.—*On the Development of the* Lycopodiaceæ. By Karl Müller †.

[With five Plates.]

§ 1. *Literature.*

The most complete researches on this interesting family which have hitherto been presented to us are certainly those of Bischoff, which he published in his 'Cryptogamische Gewächse ‡.' Since that time however the position of science has undergone such an important change, that in this family also questions have arisen which remain to be solved. Toward the attainment of this end the present memoir is contributed. I know well that there is yet many a gap to be filled up here, still I am induced to publish my observations in their present condition, as I believe them to be conclusive in reference to many points.

The history of this family up to the time of Bischoff has been given by him in his above-mentioned work. This relieves me from the necessity of entering upon it here. What has been done since, is chiefly confined to their systematic arrangement,

* See his admirable memoir, 'Ueber die Myxinoiden,' in the Berlin Transactions for 1835.

† From the 'Botanische Zeitung,' July 31, and August 7, 1816. Translated by Arthur Henfrey, F.L.S. &c.

‡ 2[te] Lieferung, Nuremberg, 1828.

and on this point Spring's observations are the most important. His labours are to be found in the 'Flora' Journal, 1838, and in the 'Fl. Brasiliensis,' pp. 106—135. I am not acquainted with a treatise of Link's, which Schleiden cites in the first edition of his 'Grundzüge, &c.*,' but it appears of very little importance to my purpose. In another memoir however by H. von Mohl†, an attempt is made to open a new path, which will be spoken of hereafter in the places bearing reference to it. Other critical observations are given by Schleiden in his work already mentioned ‡. Nothing connected, therefore, seems to have appeared upon the *Lycopodiaceæ*.

§ 2. *The Germinative Spore.*

It is well known that two kinds of spore-cases are distinguishable in the *Lycopodiaceæ*,—1. for those capable of germination, and 2. for others which apparently have no share in the reproduction. Spring calls the former *Oophoridia*, the latter *Antheridia*. In the latter expression Spring indicates no more than a morphological opposition to the Oophoridia; he did not entertain any idea of a sexual distinction §. The essential points relating to both sporangia have been long known; Bischoff has given accurate illustrations of them in his work above-mentioned. We have here therefore only to do with the spore which germinates, the development of which I have traced, as also did Bischoff, in *Lycopodium denticulatum*.

This exhibits, on the whole, a great conformity of structure in the different species in which it makes its appearance. They are more or less roundish bodies, which on those surfaces which have been in apposition with each other in the *oophoridium*, are flattened just like the smaller pollen-like spores. Therefore, since only three or four spores are contained in one of these capsules, they are spherical on the outer surfaces, that is, where they are not in contact, and on the inner side have three or four triangular faces. This is particularly distinct in *L. selaginoides*, and also in *L. denticulatum*. In others they are often quite round, for instance in *L. articulatum* and *pygmæum*.

A transverse section distinctly shows that they possess two

* Part 2. p. 82.

† Morphologische Betracht. über das Sporang. der mit Gefässen versehenen Kryptogamen. Tubingen, 1837, p. 28, &c.

‡ 2 Th. pp. 79—83. I have here usually cited the first edition, since this is probably now in the hands of most botanists. The second contains nothing new relating to this family.

§ At least I so understand Spring's words: "capsulas fariniferas et globuliferas non de essentia sed per accidens solummodo esse diversas neutiquam credo. Est omnino antithesis inter ipsas, *sexuali analogo*, licet non *eadem*." (See Fl. I. Bras. fasc. 7. pp. 106—108.)

coats. The exterior is very thick and made up of numerous cells, the walls of which are wholly confused together, so that they are often scarcely perceptible on the surface of the section. This thickening is common to the whole coat, the cells of which, by the incessant deposition of new matter in their interior, become homogeneous plates. Yet some species differ so much in this respect, that the cells are not completely thickened, but still exhibit some cavities, as in *L. articulatum*. The continued deposition of membranous substance usually causes the external coat of the spore to exhibit elevations on its outer surface. They occur especially upon walls of the cells as anastomosing ridges of irregular form (*L. articulatum*); in other spores where the walls of the cells have become almost indistinguishable, as wart-like bodies (*L. selaginoides*), or as large, compact papillæ (*L. pygmæum*). In *L. articulatum* there are, besides these larger elevations, still smaller papillæ scattered over the whole surface. They constitute a special thin membrane which may be detached from the cells lying beneath.

The *inner membrane* on the contrary is *usually* perfectly structureless and of equal thickness in all parts; it is not so firmly adherent to the outer membrane as to prevent its being detached from it. I have only found the inner membrane different from this in the spore of a single species, namely in *L. gracillimum*, that is indeed if I did not confound it with the outer membrane, which I do not believe. In this case, beneath the outer thick membrane lies a layer of *parenchymatous cells* of *tolerable size*, which could be separated from the former. I saw nothing of any other layer, like that which is present as the inner membrane in all the other spores; this therefore must be regarded as the peculiar inner layer, although it is not clear to me how this inner membrane can consist of an independent layer of cells.

In general this membrane is formed of a more or less granular substance, which is particularly evident in *L. articulatum*.

The contents of these spores consist of a granular mass which is contained free within the inner membrane. The granules are perfectly round, distinct from one another, transparent and of very variable though always small size. They still remain in this condition after being kept for years, as I can state, in confirmation of Bischoff, with regard to *L. selaginoides*. This inquirer says* of them, that they appeared to him to consist of vesicular cells, and following him, Schleiden † speaks also of a delicate cellular tissue. On the other hand, I must remark, that to me these granules appeared to be not nearly so like small cells as compact grains, since on treating them with strong tincture of

* *Ut sup.* p. 110. † Grundz. ii. p. 82. ed. 1.

iodine I could not detect any ring in their interior, and this is the first character of a hollow globule. But there can be no question at all of a cellular tissue here, and this can only be a misconception. A fluid which appears to be oily accompanies the granules at a later period, and this will be more fully spoken of hereafter.

§ 3. *The process of Germination.*

When the spore escapes from the sporangium and falls upon a suitable soil (which must be somewhat moist), it swells out by absorbing water into its interior. If we examine under the microscope a spore in this stage, on crushing or cutting it the granular matter contained is readily spread through the water upon the slip of glass, and is evidently accompanied by the apparently oily fluid already mentioned. This is also scattered through the water in the form of drops or globules of oil. To satisfy myself whether I had to do here with actual globules of oil which have *but too frequently* been described by various inquirers as forming part of the cell-contents, or with some other substance, I next endeavoured to test them with very strong solution of iodine. By the application of this, the mass became brown, firmer and more tenacious. I then added æther, and the globules were not dissolved, as must have been the case if they really consisted of a fatty matter. The mass remained tough. Moreover it still remained so when I applied hydrochloric acid, and distinctly showed by this that I had to do with a totally different substance. It is already present before the formation of cells begins and is the material for that operation, therefore I do not doubt in the least that it is the same mass which H. Mohl has briefly characterized under the very expressive name of *Protoplasma* in the 'Botanische Zeitung' (vol. iv. p. 75*).

If the process of cell-formation has already begun, when we carefully examine a spore, we find that as soon as we act upon it with iodine, some free cells always show themselves among the remainder of the cell-contents and the protoplasma, and are always coloured blue. They appear more or less round, compressed on two sides or angular, most of them however in the laterally compressed form. In the centre occurs a roundish, smaller nucleus inclosed in a coagulated mass, but in such a manner that it always appears round. Other layers, surrounding this, now present themselves, which are concentrically situated around the nucleus, and are likewise coloured blue. A gelatinous, coagulated and thicker layer envelopes the whole in the form of a cell, which therefore wholly identifies itself with an

* Annals Nat. Hist. vol. xviii. p. 3.

"amylum-cell." I regard it in fact as actually such, and likewise as one of the earliest stages of cell-formation. They soon lose the character of amylum-cells, since they become transformed into another substance which is coloured brown by iodine, and which again wholly incloses the nucleus like the protoplasma, only in another situation, as I shall at once show further on.

I must here however make mention of a peculiar phænomenon which remains totally inexplicable to me. When I treated these cells with iodine, æther and hydrochloric acid, I found that their deep indigo blue colour was changed and they became reddish or even wholly colourless. When I now touched the fluid in which they swam, the slight agitation instantly restored the blue colour. In a state of rest however this soon disappeared again, and reappeared when the fluid was touched, and so on. But if the cells had become quite colourless, immediate contact with some object, either of metal or wood, was necessary, and then the blue colour again instantly seized upon one point—it appeared to me to be the nucleus—and extended itself over the whole cell. I have met with this remarkable phænomenon in two spores. In spite of every endeavour I have not hitherto been able to find it again, although I have applied an infinite variety of mixtures of the three reagents, and also used the hydrochloric acid first and the others afterwards, or these first and that last. It is possible that a peculiar stage of the life of the cell may be here requisite, which therefore I have not again lighted on. I remark however expressly, that I found this changing of colour in all the blue-coloured cells of those two cells, and consequently it cannot be attributed to any optical illusion, and so much the less that I could continue this play of colour as long as I liked. Perhaps some one else may succeed in observing this phænomenon in similar cells and by more close observation discover the law, and it is for this reason that I have here called attention to it.

In the interior of the perfect young cell is found a collection of that granular substance which has been already described as the spore-contents, or only a single large granule as a nucleus, always in the centre. Around it, as has been stated above, a substance similar to, probably identical with the protoplasma, has already been evenly deposited, the outer contour of which, firmer than the inner substance, forms the whole into a cell. The protoplasma has been thus equably deposited round the granules, because these lie exactly in the centre of the cell, and this position is an evidence of the importance of the granules for cell-formation. They are, as often in the process of crystallization, only the point of attachment, and thus the special foundation for the substance deposited around them, just as we explain the forma-

tion of the oolite limestone or urinary calculi, &c., the nucleus of which is a granule, which is afterwards to be found in the centre. This analogy is the more striking here, since in these amylum-cells the contents have been likewise deposited concentrically around the nucleus, as in these crystalline formations. Some authors draw a parallel between the processes of cell-formation and crystallization, and in fact I see no reason to object to this view.

From these observations this cell-formation appears to be somewhat different from the usual kind depending on cytoblasts. Here we have no cytoblasts but only a simple nucleus as a central organ; around this the protoplasma is deposited till the outermost surface hardens; in the other formation, protoplasma is indeed similarly deposited round a nucleus and so forms the cytoblast and *through this* a cell, but then the process is of somewhat longer duration, as the outer surface of the cytoblast must first become softened and extended to form a membrane, while in the other case such solution and extension does not take place, and the outer surface of the protoplasma is immediately transformed into "membrane substance." Thus we can, if we like, with perfect right in our case, call the cells *cytoblasts* which develope directly into cells, since they soon become hollow, although the protoplasma is not perceptible without the addition of iodine. As a whole however it comes to the same thing, with this distinction only, that in one case the protoplasma is not precipitated, as in the cytoblast, in the form of a granular and distinctly visible, compact mass. In both cases the nucleus is to be considered as the central organ, as therefore especially the basis of cell-formation. The cells now become hollow by the absorption of the protoplasma. This does not take place quite completely at first, for, exactly as in the cytoblasts, the nucleus comes to be suspended in the centre by thin, persisting filaments of protoplasma, till at last both filaments and nucleus disappear.

Thus these observations wholly agree with Mohl's so far, as here the protoplasma is deposited round the nucleus exactly as he describes. The formation of membrane alone by the direct hardening of the outer surface of the protoplasma deposited round the nucleus appears to be a new modification of cell-formation. I am the less inclined to believe myself deceived here, since I could never find any true cytoblasts, and I saw that the cells were already filled with protoplasma in their earliest stage. I must particularly remark, that the earliest cells inside the spore certainly originate independently. I never found secondary-cells within parent-cells.

This formation of cells commences at a particular spot on the inner spore-membrane. The spot is characterized by the fact

that the membrane upon which the cells are deposited are coloured blue by iodine, while the rest of the surface becomes brown. It is consequently partly altered chemically and indeed into a substance containing starch. It is thus qualified for its further extension, since being more porous than the rest of the membrane it can more readily acquire new parts by interstitial deposition. The cells apply themselves so firmly upon this spot, that they appear to grow together with the inner membrane.

Lastly, the firm outer spore-membrane is broken through, since the bud grows out from the interior of the spore in the form of a blunt, rounded cone. I distinguish it here by the name *germ* (*Keimkörper*). Its cells are yet quite white and transparent. The place however where the outer spore-membrane opens, is, according to Bischoff, always where the three elevated ridges meet, consequently at the point of union of the three triangular faces of the spore.

At this period the process of germination begins to be visible externally. But the whole of the contents of the spore are not yet by any means transformed into cells; on the contrary, the "germ" is yet of very small circumference, and more or less truncated at its base in the interior (Pl. II. fig. 4 *b*).

If the spore-membrane is first ruptured and the primary germ drawn out, it exhibits a growth in two opposite directions. One indicates the formation of the stem and the foliaceous organs, the other the formation of a rootlet. The former appear in the shape of an ovate mass, the latter as a little cone. Both stand quite upright upon the perpendicular spore (Pl. II. fig. 1). Subsequently they both are curved into a much more horizontal direction, so that, since the stem and root come to be placed exactly on a level, the spore becomes transposed into a horizontal position (Pl. II. figs. 5, 11, 13, 15—19). This position only alters, if the elongating stem subsequently becomes irregularly curved.

If we now examine more closely the whole development, we have here to consider four masses visibly distinct from each other: 1. *the germ*; 2. *the rootlets*; 3. *the stem,* and 4. *the terminal bud,* which organs will be treated of in the following paragraphs.

§ 4. *The Germinating Plant.*

1. *The germ* (*Keimkörper*). This body is composed of an assemblage of very small, parenchymatous and transparent cells, rising to the height of a few lines above the spore, and is here provided with many little radicle fibrils which are merely elongated cells of the outer surface (Pl. II. fig. 1). Within the spore, its base is truncated (fig. 4), and it does not become per-

fectly round until a later period, when it gradually produces a number of new cells upon the base. This however takes place but slowly, and it is seldom that the whole contents of the spore become completely transformed into cells before the plant has attained a condition in which its self-sustaining power has become tolerably evident. Considered in connection with the plant, the "germ" in its perfect condition is pear-shaped, a neck being formed where it breaks through, and rises from the spore (fig. 4 *a*). At a later period it disappears, apparently through decomposition.

2. *The rootlet.* This first appears, as I have already said, under the form of a little conical process (fig. 1). Its substance originally consists of an apparently structureless, undeveloped deposit of roundish granules which appear of a somewhat reddish colour. The apex however of the radicle is more transparent. It soon grows longer, forms parenchymatous, elongated tissue, and many of its epidermal cells become radicle fibrils. The inferior extremity still remains, as at first, more transparent, *i. e.* having the reddish substance and the brighter point, which is indeed the condition of newly-formed parts generally. I have never been able to find any little spongy investment upon this end, and I therefore know not what Bischoff alluded to under this character. I have seen a number of radicles in all stages, and have carefully examined them under the microscope; but an organ of this kind, such as we find in *Lemna*, never presented itself to me. As to the vessels, which the root subsequently exhibits, they are formed after those of the stem. The growth of the root generally is slower than that of the last-named organ.

The subsequent course of development of the radicle is an elongation and dichotomous ramification. As soon as the plant has become more independent, several roots are developed at the base of the stem, and these present characters exactly similar to those of the first. Like this they originate from the extension of the "germ," and by their frequent occurrence on the same point of attachment they render it very doubtful whether we ought to consider the root first developed as a chief root (*Hauptwurzel*) as Schleiden does*. It is indistinguishable from those subsequently produced, and only has the advantage over them in the fact that it is the first formed and is on a level with (its axis corresponding with that of) the stem. The only question is therefore how much importance is to be attached to this last circumstance.

The radicle fibrils subsequently appearing upon the foliaceous branches do not differ from these roots in their structure and development. But these cannot be spoken of until we come to the formation of branches.

* Gründzuge, ed. 1. ii. 79.

3. *The stem.* The future situation of this is very evident in the "germ" as a dark, circular expanded spot. This occurs near the middle, and consists of cells filled with material for development (Pl. II. fig. 4 *a*). This is the special point of vegetation for stem and root, and the boundary of the germ. By the time indeed that the stem has become so far visible that we can distinguish clearly in the main axis, a terminal bud and an inferior, cylindrical, cellular portion (the stem itself), the vessels of the stem and the terminal bud have already set out from that spot. At a subsequent period the vessels of the root also originate at the same place; so that this organ must be accounted part of the main axis, notwithstanding that its originally erect and independent development, apparently unconnected with that of the bud of the stem, appears to indicate the contrary.

The number of the vessels always amounts to two. This number indeed occurs almost universally in *Lycopod. denticulatum,* since both the roots and the subsequently formed branches divide dichotomously. At a later period, it is true, these two vessels appear to become blended, but this union is only apparent, and in the perfect stem the two orifices of the vessels are always easily demonstrable in a transverse section.

In their first stage they decidedly contain air, since when we bring a stem at this period of its development under the microscope, the vascular bundle appears all dark and filled with air-bubbles (fig. 5 *a*). This arises probably from the circumstance, that as the germinating plant lies in water, the latter penetrates to a certain extent, accumulates in particular places among the air contained in the vessels, and thus somewhat compresses it. This is the more likely, since the vessel soon becomes so filled with water, which could only be taken up through endosmose, that the air is completely driven out, or perhaps in great part mixed with the fluid.

This stem now constitutes the whole of the as yet undivided, main axis, and may thus be clearly distinguished from the branches next produced. What the condition of this may be in the other *Lycopodia* which do not belong to the genus *Selaginella,* I am unable to say. It elongates only up to a certain limit, while the terminal bud is becoming perfected at its apex.

4. *The terminal bud.* When the stem is only just distinguishable, this organ is found upon it as a little head, of ovate form and of a green colour. Within appear distinctly two, much smaller, ovate bodies, situated opposite one another, which are visible through the external, green envelope (fig. 1 *d,* fig. 2 *a,* a lateral view), in which one body is in front of the other, and so only one is visible.

Examined more narrowly, the terminal bud is seen to consist

of two outer leaves, which are so closely united that they may be said to fit one another like the two hollow hemispheres of a bullet-mould (fig. 3 *a*, where they are separated to some extent by slight pressure between two glass plates). I distinguish them by the name of "*bud-envelopes*" (*Knospenhüllblätter*), because the two inner bodies which they inclose are already in fact two *buds*, in which may be found the types of the complete organs of the future branches. They are therefore two *buds of ramification* (*Astknospen*). A vessel in course of development proceeds toward each of them from the point of vegetation of the stem (Pl. II. fig. 4 *c*).

Since however all the organs have already been contemporaneously produced in the youngest condition in which it becomes visible to us, I prefer to describe them in a somewhat more advanced stage of development, because at their first production the individual organs are too minute, to allow of our giving a sufficiently clear representation of them, since it is scarcely possible to prepare them for examination.

a. The bud-envelopes. They are broad, somewhat oval, almost roundish and having transparent denticulations on the borders, in other parts of a green colour, and in all these characters quite indistinguishable from the leaves of the branches which succeed. They possess but one character which does not and indeed cannot belong to the leaves of the branches. They possess, namely at their base, which, broader than that of the branch leaves, half embraces the stem, a thin, membranous, transparent, cellular membrane, which also half incloses the stem, and usually appears as if torn more or less regularly at the truncated base. This is not organically connected with the stem, but only an appendage to the "bud-envelopes" (figs. 5—7).

I regard this appendicular membrane as a remnant of the internal spore-membrane. For this does not become detached from the terminal bud until after a considerable period, and then remains with its upper portion (on which, as I have already said, the primary cells of the "germ" are so closely applied that they grow together with it) also further organically connected with the base of the "bud-envelopes," until the developing stem in the course of its elongation tears through the spore-membrane, exactly like the calyptra and vagina of the Mosses, where, as here, the lower portion remains attached to the base of the axis, while the superior portion is carried upwards. This explanation is confirmed by the fact that this membrane always looks as if it had been torn, and the other portion of the spore-membrane is still to be observed upon the base of the young stem (fig. 5). It is however cellular, while the remaining portion of the spore-membrane consists of a homogeneous membrane, and this appears to

me to arise from the following circumstances: those cells which were originally produced in the spore and became organically connected with the spore-membrane, belong peculiarly to this last structure and form a special membrane upon the inner coat of the spore as it becomes attenuated by its external prolongation, for they have a flattened form and must be regarded as belonging to the spore-membrane only, since they are perfectly free and distinct from the other cells of the "germ." In fact the whole course of development exhibits it in this light.

That these "bud-envelopes" were formerly regarded as actual cotyledonary leaves, may be accounted for to a certain extent, by the *long* time during which they remain visible upon the young plant. But they cannot naturally be compared to cotyledons, since they proceed from no embryo, and are in no wise different from the leaves of the branches. But they have the same function on the young "germ," as cotyledonary leaves, to nurse, that is, to defend the young buds of ramification, until they have attained a self-sustaining degree of development.

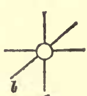
b. The buds of ramification. As soon as the "bud-envelopes" unfold, *i. e.* have become turned back, the buds of the future branches may be very distinctly perceived between them, opposite to each other. Each occurs in the middle of the leaf, and placed in such a manner that its side is turned toward the internal cavity of its enveloping leaf (fig. 6 *a*). Therefore when by their further unfolding the two buds become turned outwards in opposite directions, a cruciform arrangement is produced with the "bud-envelopes" (fig. 11). Every leaf which is inclosed in the bud follows the same course. If we examine, with a view to ascertain this, the bud represented in fig. 6, and unfold it, another leaf presents itself (fig. 8), which, hollow and folded upon itself, may contain yet more according as the bud has become developed, till at last we reach the axis on which the leaves are produced (figs. 9, 10). The development of these leaves I prefer to describe as seen in the perfect plant.

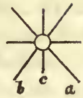
The unfolding of the leaves takes place according to the following plan:—

1. Two "bud-envelopes" (fig. 5).
2. Two *branch*-leaves. These deviate 90° from the first, and form a cross with them (fig. 11) *a*.

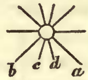

a

3. Two leaves, which again cross the cross already formed. They stand therefore at an angle of about 45° from the "bud-envelopes," and are at this period the smallest leaves of the bud distinguishable by unassisted vision (fig. 12) *b*.


b a



4. This arrangement does not long persist, for two new leaves arise between the last two *c*, and affect the position of the remainder, so that *a* is pushed aside to the extent of 45°. *c* stands almost exactly at an angle of 90° with the bud-envelopes (fig. 13).



5. Then two more leaves appear in each bud which deviate almost equally about 90° *d*.

The alternation of the first two leaves *a b* may already be remarked here, whereof *b* is placed higher up on the axis of the branch than *a*. Both are attached to the lower side of the axis, and are the larger leaves. *c* and *d*, on the contrary, are developed upon the upper side of the axis of the branch, and are here (in *L. denticulatum*), as almost universally in *Selaginella*, smaller than the preceding. Spring calls them *folia intermedia.*

Between the last and first leaves lies the axis of the branch, which now becomes elongated, while in the next place two other larger leaves become visible, whereupon two *folia intermedia* appear on the upper side, &c.

Four series of leaves therefore are now distinctly visible upon the axis of the branch, two above and two below. Of these four series two on one side always correspond so with each other, that first a large leaf is situated on the under, and a *folium intermedium* at some distance on the upper side. But if all four series are now compared, a *folium intermedium* is normally opposite a large leaf situated on the other (under) side (figs. 15—18); consequently two series of leaves always alternate with each other.

The two opposite buds developing in this manner, the germinating plant becomes bifurcated. But one of the buds is sometimes abortive, and then of course there is no bifurcation; the single bud developes into a branch, and this subsequently undergoes a bifurcate division (Pl. II. figs. 18, 19).

c. Accessory organ. I come now to an organ which is contained in the terminal bud and contemporaneously formed, and which, so far as I know, has never hitherto been observed. It appears to me that it must be of importance to the plant, since its occurrence is constant.

It is a body, usually pyriform, composed of a number of delicate, transparent, parenchymatous cells. It is consequently bellied out at its base and attenuated into a neck above (Pl. III. fig. 1). It is compressed on two sides, but in such a manner that its borders are not acute, but rounded (fig. 2). The borders are entire, and the apex alone, which is always truncated, has the uppermost cells irregular and more or less rounded. Within them are parenchymatous cells usually smaller, normally hexa-

gonal, with horizontal walls (figs. 1, 3). The apex of this organ is often bifurcated (fig. 4); the forks however at their apices pass gradually into cells like those we have before met with (figs. 1, 3). By a transverse section we find that the interior also is filled by layers of delicate parenchymatous cells (fig. 2). The same is seen in a longitudinal section (fig. 5), in which it may be clearly perceived, the external layer of cells regularly inclosing the remaining mass of cells. The apex is prolonged out into a few layers of cells (fig. 5); finally into a single one (fig. 1). Moreover the cells of the swollen, expanded base are filled with a finely granular, somewhat reddish matter, which however is only developed here into *membrane-substance,* since it probably forms new cells to multiply the numbers, whereby the bulging circumference of the basis is enlarged. No other kind of cell-contents is present (fig. 1).

This singular organ is present in all stages of the plant's existence. In the terminal bud of the youngest "germ" it is already perfect, and is situated between the bud of the branch and the bud-envelope (Pl. II. fig. 6 *b*). It is again met with in every successive leaf, in the large as well as in the "intermediate." In the terminal bud even of the perfect branch it is produced soon after the development of the leaf from the stem, and is always placed between them. Equally constant is it between the oophoridium and the antheridium and their involucral leaves. It is particularly large between the oophoridium and its involucre.

With respect to the development of this organ, it appears both in the terminal bud of the "germ" and that of the branch as a more or less circular plate (Pl. III. figs. 6, 7, 8, 8 *a*). In the first-named bud its very delicate cells are already filled with that often-mentioned reddish substance, by means of which the organ becomes more extensively developed (figs. 6, 7). In the second the plate is *frequently* quite transparent and devoid of that substance (fig. 8). The plate, now of equal thickness all over, then extends itself upwards into an attenuated neck, rounded at the top (Pl. III. figs. 9, 10). This is usually more transparent than the base of the organ, which also in the leaves of the terminal bud of the branch soon becomes filled with the same reddish contents. Through this elongation, however, the base appears as if thicker; this indeed is quite natural, as it has not yet become extended. But the cells speedily become developed in this part of the organ on the side next to the leaf. By this means the organ acquires a bulging form in this situation (Pl. III. fig. 5 *a*), while the side turned toward the axis of the branch is *usually* much more perpendicular (fig. 5 *b*). As soon as the general form is perfect, the top of the organ becomes

truncated by the cells of this part separating from one another, so that it looks as if it had been torn (figs. 1, 3), and the organ is then perfect. In this shape it continues until the end of the annual growth of the plant, at the end of which period it withers with the leaves, apparently without acquiring any further development, since we never find anything in its interior different from what has already been described.

But the nature of its connexion with the longitudinal axis of the branch is to be seen by making a delicate longitudinal section. In this we observe that it is neither attached to the leaf nor laterally upon the axis of the branch. It stands exactly between the two, and is united by several larger, transparent and empty cells, usually two, with the green parenchyma which passes off from the axis to the leaf. The organ never receives a branch from the vascular bundle, although the vascular bundle, which is given off from the axis to the leaf (figs. 5 *c*, 11 *a*), runs close under it. If at a later period we cautiously detach a leaf with the whole of its base from the stem, we always find upon it, *i. e.* upon its thickened base, this organ removed with it, and it would thence appear as if it really belonged to the leaf and had been formed from the parenchyma of the same; but the history of its development speaks most decidedly against this last view.

It is difficult, with respect to this enigmatical structure, to attain a view which shall give us even an approximation to its real import. Even the history of development here leaves us at fault, and a true solution of this question will probably only be found when we know how widely this structure is extended throughout the Lycopodiaceæ, in how many different forms it appears, and when perhaps anomalies in its mode of formation shall be met with. Meanwhile its analogues appear to me to occur in those buds which are often met with in the axils, between leaf and stem, in various other Cryptogamic plants, as in the axils of the leaves of *Bryum annotinum* and others. Here however it must not be forgotten that in our case the cells never acquire green contents, while those often do. They consequently cannot be regarded as buds. Are they little branches? are they radicle structures? Reasons on both sides may be brought forward, which to me are yet inadequate to solve the question. I commend it therefore to the attention of more skilful investigators.

[To be continued.]